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ABSTRACT

Described in this paper is an instructional model for higher-order thinking skills that is mainly based on research and theory about the processing of information in linguistic form. The model itself, basically a framework within which teachers can interact with students about information, has 10 categories of thinking skills: recognition of concepts, relationships, and patterns; information reconstruction, evaluation, and extrapolation; problem solving; and knowledge of basic input-output processes, content-specific tasks, and self as learner. In addition to briefly describing other commonly used models of thinking skills and noting criteria for thinking-skills model development, the first section of the discussion characterizes each skill, identifies the theoretical base from which it was devised, and reports research supporting its instructional utility. The second section outlines general instructional implications of the thinking skills model. It is concluded that, in its present form, the model can be implemented at any grade level within any instructional framework because its focal point is the teacher and his or her interaction with students. A 9-page list of references concludes the document. (RH)

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THE THEORETICAL FRAMEWORK FOR AN INSTRUCTIONAL MODEL OF HIGHER ORDER THINKING SKILLS

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INTRODUCTION

There is a growing national awareness of the need for direct instruction in higher order thinking skills within public education. The Education Commission of the States, in a report entitled "The Information Society: Are High School Graduates Ready?" (1982), states that "survey results indicate that today's minimum skills are demonstrated successfully by a majority of students. Higher order skills, however, are achieved only by a minority of 17-year-olds. If this trend continues, as many as two million students may graduate in 1990 without the skills necessary for employment in tomorrow's marketplace." (p. 12) Similarly the recent presidentially-commissioned report, A Nation at Risk (1983), in its list of implementing recommendations for "Recommendation A: Content", identifies specific higher level thinking skills they feel should be more "rigorously addressed" (e.g., evaluation, estimating, interpretation). Edward de Bono (1980) charges that the greatest fallacy of education is that thinking skills are automatically bestowed on those with high I.Q. and consequently need not be taught. De Bono also states that direct instruction in thinking skills should be a top educational priority.

Such a task is not easily accomplished in the current educational setting for a variety of reasons. Two of the most important are: 1) the difficulty with which higher level skills are evaluated, and 2) the lack of models which might be easily translated into instructional practices. Relative to the first reason, Doyle (1983) states that accountability drives the academic tasks presented to students. As a result, students are especially sensitive to cues that signal

accountability or define how tasks are to be accomplished (Carter & Doyle, 1982; King, 1980; Winne & Marx, 1982). Students tend to take seriously only those tasks for which they are held accountable. Given the complexity of most higher level processes many teachers avoid evaluation of higher level tasks and, consequently, indirectly transmit the message to students that they are not important.

Relative to the second reason, Doyle (1979) argues that the immediate task of teaching in classrooms is that of gaining and maintaining the cooperation of students. He suggests (1983) that the research literature illustrates the commonsense notion that teachers are required to think about much more than academic tasks in planning and conducting academic tasks. Given that their need for classroom control is perhaps the top node on a needs hierarchy, teachers will invariably gravitate to those techniques with which they are familiar. Unfortunately, there are few widely used models for direct instruction in higher order thinking skills although studies which attempted to improve students' use of higher level strategies have had favorable results (Hansen, 1981; Reys & Bestgen, 1981; Carnine & Stein, 1981; Cullinan, Lloyd & Epstein, 1981; Lloyd, 1980). Doyle (1983) comments that these circumstances make for an environment not conducive to instruction in higher order thinking skills: "The central point is that the type of tasks which cognitive psychology suggests will have the greatest long-term consequences for improving the quality of academic work are precisely those which are the most difficult to install in classrooms." (p. 180)

The purpose of this paper is to describe an instructional model for higher order thinking skills and the theoretical base from which

that model was developed. Prior to this we should consider some of the other commonly used models of thinking skills.

THINKING SKILLS MODELS

Although not widely used, models of cognitive processes are not new to education. By far the most commonly used model of thinking skills within education is that developed by Bloom (1956). It is only fair here to state that Bloom did not originally intend his system to be a model of cognitive skills. Rather his purpose was to develop a taxonomy of educational objectives. Bloom's taxonomy (as it has come to be known) includes six levels.

1.00 KNOWLEDGE

Knowledge, as defined here, involves the recall of specifics and universals, the recall of methods and processes, or the recall of a pattern, structure, or setting.

2.00 COMPREHENSION

This represents the lowest level of understanding. It refers to a type of understanding or apprehension such that the individual knows what is being communicated and can make use of the material or idea being communicated without necessarily relating it to other material or seeing its fullest implications.

3.00 APPLICATION

The use of abstractions in particular and concrete situations. The abstractions may be in the form of general ideas, rules of procedures, or generalized methods. The abstractions may also be technical principles, ideas, and theories which must be remembered and applied.

4.00 ANALYSIS

The breakdown of a communication into its constituent elements or parts such that the relative hierarchy of ideas is made clear and/or the relations between the ideas expressed are made explicit. Such analyses are intended to clarify the communication, to indicate how the communication is organized, and the way in which it manages to convey its effects, as well as its basis and arrangement.

5.00 SYNTHESIS

The putting together of elements and parts so as to form a whole. This involves the process of working with pieces, parts, elements, etc., and arranging and combining them in such a way as to constitute a pattern of structure not clearly there before.

6.00 EVALUATION

Judgements about the value of material and methods for given purposes. Quantitative and qualitative judgements about the extent to which material and methods satisfy criteria. Use of a standard of appraisal. The criteria may be those determined by the student or those which are given to him.

Bloom's model is comprehensive and has some intuitive appeal. The principal value of the taxonomy has been its impact on educational measures, specifically teacher made tests (Hopkins and Stanley, 1981): "A teacher who has been exposed to the taxonomy, with illustrations of how higher mental processes can be measured (often objectively), can no longer be satisfied with a test that measures only rote learning of isolated facts." (p. 174) The main shortcoming of the taxonomy is its lack of specificity: that is, Bloom does not adequately describe the constructs used to define the six levels of processing. For example, consider Bloom's description of knowledge - "the recall of specifics...universals ...methods...processes...patterns...structure... setting." Without an operational definition of specifics, universals, methods, etc., Bloom's definition of knowledge is limited as an instructional tool. A quick review of the remaining levels of the hierarchy reveal that all levels contain weak or nonexistent descriptions of key constructs:

Comprehension:	"understanding...such that...individual knows what is being communicated."
Application:	"use of abstractions"
Analysis:	"breakdown of communication into its constituent elements"
Synthesis:	"putting together of elements"
Evaluation:	"judgement about value of material"

It is this lack of specificity that perhaps accounts for the confusion among educators about levels of the taxonomy. Several investigators (McGuire, 1963; Kropp, Stoker & Bashaw, 1966; Stanley and Bolton, 1957) report that judges frequently disagree on the taxonomy level of test items. Indeed, among the higher levels of the taxonomy agreement is the exception rather than the rule (Poole, 1972; Fairbrother, 1975; Wood, 1977).

A more recent but equally as general a model of cognitive skills is that suggested by the College Board (1983). Although they attempt to subdivide reasoning skills into more distinct areas their descriptions are still so general as to be almost impossible to translate into instruction at the individual teacher level.

- The ability to identify and formulate problems, as well as the ability to propose and evaluate ways to solve them.
- The ability to recognize and use inductive and deductive reasoning, and to recognize fallacies in reasoning.
- The ability to draw reasonable conclusions from information found in various sources, whether written, spoken, or displayed in tables and graphs, and to defend one's conclusions rationally.
- The ability to comprehend, develop, and use concepts and generalizations.
- The ability to distinguish between fact and opinion.

Most other models of thinking skills including that by De Bono (1983) suffer from this same lack of specificity. Consequently, a major goal of this model is to define the various levels of cognition in sufficient detail to be easily translatable into instructional techniques. Other than specificity there are a number of criteria

which should be used as guidelines for thinking skills model development.

Sternberg (1983) has suggested a number of criteria for thinking skills training programs. The basic tenets underlying Sternberg's criteria are that:

1) training models should be based on sound cognitive theory
2) training models should be relevant to the needs of students
3) training models should be empirically validated

De Bono (1983) offers less rigorous but more educationally relevant criteria for thinking skills training: 1) the model must be easy to use, and 2) must have useful effects. In the next section I will attempt to show that the proposed model is based on sound cognitive theory and in many cases is already empirically validated. The relevance of the model is a function of its "coverage" of important educational issues. That is, if the theoretical base for the model draws from educational theory and research currently considered "vital" then we can conclude that the model has relevancy. Finally, the issue of "ease of use" will not be addressed here. I am making the assumption that the most needed and powerful educational innovations may not be easy to implement. This appears to be the position taken by those who have undertaken large scale studies of schooling (Goodlad, 1984; Boyer, 1983).

THE MODEL

The model presented here has ten categories of thinking skills. These are not presented as a hierarchy but rather as an arrangement of thinking skills for instructional purposes. Any hierarchy of thinking skills defines the component parts in such a way as to make them appear

to be neatly organized in the fashion portrayed by the hierarchy. In reality, sets of skills or processes interact in such a highly complex way as to be indefinable in a linear fashion. To this extent any hierarchy or list of thinking skills is by definition invalid. However, as an organizational and instructional tool lists and, even hierarchies can be very useful. It is in this spirit that the following is presented:

1) Recognition of concepts
2) Recognition of relationships
3) Recognition of patterns
4) Reconstruction of information
5) Evaluation of information
6) Extrapolation of information
7) Problem solving
8) Knowledge of basic input/output processes
9) Knowledge of content specific tasks
10) Knowledge of self as learner

Of course, as listed above the skills within this model are as abstract as those within any other model. In the remainder of this section we will expand the definition of each area and identify the theoretical base from which it was devised and the research which supports its utility as an instructional tool. Before doing so, I should state that much of the model is based on research and theory about processing of information presented in linguistic form (e.g., information that is heard or read). Given the recent findings in the school effectiveness literature (Rosenshine, 1979; Stallings, 1980; Stallings et al., 1978) namely that most time spent in academic work involves either listening, speaking, reading, or writing, this seems quite appropriate.

Recognition of Basic Concepts

One of the first lines of processing of information presented in linguistic form is the recognition of words and their meanings. It is

certainly true that a reader or listener does not process or even attempt to process all words when reading or listening. This has been illustrated by Goodman (1967) and Smith (1978). However, it is also true that unless a critical mass of key words are recognized and understood immediately (automatically) processing breaks down very quickly (La Berge and Samuels, 1974). The ability to recognize and understand the words used to represent information, then, is a fundamental thinking skill or ability. Here, we are actually discussing concept recognition rather than word recognition. Concepts are elementary particles of thought. Klausemeier and Sipple (1980, p. 4) state that "concepts provide much of the basic mental material for thinking. They enable the individual to interpret the physical and social world and to make appropriate responses. Without concepts with which to think, human beings like lower form animals would be limited mainly to dealing with sensorimotor and perceptual representations of reality that are closely tied to immediate sensory experiences." (p. 4)

A concept is the "socially accepted meaning of one or more words which express the concept" (Klausmeier and Sipple, 1980, p.22). For example, the word dog is a label society uses to represent the conceptualization of a set of four-legged animals with certain characteristics. Vocabulary knowledge, then, is an indicator of one's concept knowledge. In fact, vocabulary knowledge could be operationally defined as the isomorphism between an individual's store of concepts and the labels society uses to represent those concepts. If this perspective is at all true, we can say that vocabulary development is akin to concept development.

Anderson and Freebody (1981) report that the strong relationship between vocabulary and general intelligence is one of the most robust findings in the history of intelligence testing. They also state that

an equally consistent finding is that word knowledge is strongly related to reading comprehension. Given the strength of relationship between vocabulary development and related academic tasks it seems evident that an instructional methodology which increases a student's vocabulary might also increase the student's ability to process information in general. How is vocabulary learned and taught? Mezynski (1983) sites four theories or "positions" concerning vocabulary development: 1) the aptitude position, 2) the access position, 3) the instrumental position, and 4) the knowledge position.

The aptitude position (Hunt, 1978) suggests that correlations between vocabulary scores and achievement scores are due to a third factor: a general verbal aptitude. This might be likened to what has been called the "g" factor (Holmes, 1976). The aptitude position implies a capacity that is relatively immutable. There are few instructional implications for this position. Basically, it attributes vocabulary development to innate characteristics which are relatively unaffected by instruction intervention.

The access position considers vocabulary ability as an amalgam of potentially trainable subskills. Proponents of this position are interested in the "automaticity" of word recognition (La Berge and Samuels, 1974; Lesgold and Perfetti, 1978; Perfetti and Lesgold, 1977). That is, they feel that a vocabulary item becomes truly usable to a student only when s/he can recognize and understand it immediately. The instructional implication of this position is that "practice and time" spent on vocabulary instruction are key factors in developing a store of instantly recognizable concepts.

The instrumental position states that vocabulary knowledge is a key (perhaps the most important) component of processing information

presented in written or oral form. Here the instructional implications are straightforward; given that vocabulary knowledge is the entry point for comprehension of verbal information, the systematic teaching of vocabulary should be a high educational priority. In effect this was Becker's (1977) recommendation after a thorough analysis of the effects of various instructional programs on the "disadvantaged." He concluded that a systematic program of instruction on the 7,000 "basic" concepts as defined by Dupuy (1974) should be a major thrust of education.

The knowledge position stresses two points: 1) knowing a word well implies knowing a lot of words related to it; 2) it is this larger "chunk" of information that is most important in terms utilizing vocabulary/concept knowledge. That is, a new vocabulary item is probably entered into an individual's store of concepts by attaching it to appropriate chunks or clusters of related concepts. The instructional implication of the knowledge position is that vocabulary items should be presented and reinforced in the context of the general semantic cluster to which they logically belong. This assertion is supported by the research of Klausemeier and Sipple (1980) and by the major review of the concept development research by Tennyson and Park (1980).

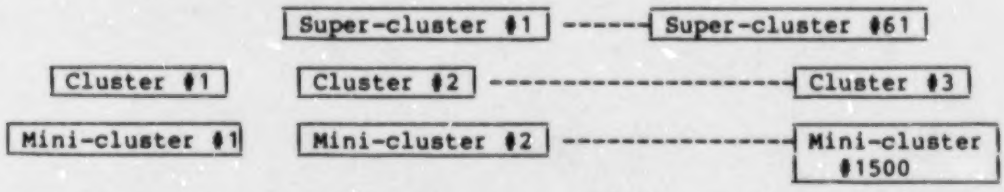
In Mezynski's (1983) review of eight vocabulary studies she implied that broad, systematic, long term training in vocabulary using an approach in which words are taught in semantic groups increases students' vocabulary knowledge and their use of vocabulary to comprehend written information. This finding encompasses the access, instrumental and knowledge positions. That is, the overall goal of

vocabulary instruction should be to increase the number of words that a student can access "automatically" (the access position). This is best accomplished by systematic, long term instruction (the instrumental position) using a technique which relates new concepts to known concepts or to a student's schemata relative to the new concept (the knowledge position).

Organizing words into clusters or semantic groups for vocabulary instruction or concept development is not a new educational idea. Such an approach is similar to what is commonly called "mapping" or "webbing." Johnson and Pearson (1978) suggest that clusters of vocabulary items might be drawn from the thesaurus. As effective as this procedure might be in terms of teaching new vocabulary words, it can still be considered a "hit and miss" approach at best in terms of coverage. As Anderson and Freebody (1981) point out, the distribution of word usage is highly unbalanced. That is, relatively few words/concepts constitute a vast majority of the words actually used. For example, of the 86,741 words listed by Carrol, Davies and Richman (1971), over 40 percent of them appear only once within the corpus analyzed. This suggests that there might be a small number of clusters or chunks of concepts which account for most of the vocabulary words commonly used in English. If these basic clusters could be identified, they might be used as a powerful instructional tool.

For this purpose, 7230 words from elementary school textbooks were classified (Marzano, 1984a, 1984b) into three levels or groupings of clusters: 1) super-clusters, 2) clusters, and 3) mini-clusters. Super-clusters are the largest organizational chunks. There are 61 of these. That is, the 7230 vocabulary words were organized into 61 broad

semantic categories. Clusters are groups of words with closer semantic ties than super-clusters. There are 430 clusters. We might say that super-clusters are clusters of clusters. Finally, mini-clusters are groups of words with the strongest semantic ties. There are over 1,500 of these. The organization scheme of the various cluster levels can be diagrammed in the following way:



As is the case with individual words, a relatively small proportion of the super-clusters account for most of the words in the 7230 word corpus. Below, the relative frequency and cumulative relative frequency for each super-cluster are reported.

Super-Cluster	Relative Frequency	Cumulative Relative Frequency
1. Occupations	.0503	.0503
2. Types of Motion	.0443	.0946
3. Size/Quantity	.0428	.1374
4. Animals	.0399	.1773
5. Feelings/ Emotions	.0390	.2163
6. Food Types/ Meal Types	.0364	.2527
7. Time	.0347	.2874
8. Machines/ Engines/Tools	.0337	.3211
9. Types of People	.0328	.3539
10. Communications	.0325	.3864

Super-Cluster	Relative Frequency	Cumulative Relative Frequency
11. Transportation	.0284	.4148
12. Mental Actions/ Thinking	.0267	.4415
13. Non-emotional Human Traits	.0242	.4657
14. Location/ Direction	.0238	.4895
15. Literature/ Writing	.0237	.5132
16. Water/Liquids	.0227	.5359
17. Clothing	.0223	.5582
18. Places Where People Live/ Dwell	.0213	.5795
19. Noises/Sounds	.0198	.5993
20. Land/Terrain	.0196	.6189
21. Dwellings/ Shelters	.0195	.6384
22. Materials	.0194	.6578
23. The Human Body	.0177	.6755
24. Vegetation	.0160	.6915
25. Groups of Things	.0160	.7075
26. Value/ Correctness	.0149	.7224
27. Similarity/ Dissimilarity	.0149	.7373
28. Money/Finance	.0141	.7514
29. Soil/Metal/Rock	.0141	.7655
30. Rooms/ Furnishings/ Parts of Dwellings	.0134	.7789
31. Attitudinals	.0133	.7922
32. Shapes/Dimensions	.0124	.8046
33. Destructive/ Helpful Actions	.0120	.8166
34. Sports/Recreation	.0111	.8277
35. Language	.0111	.8388
36. Ownership/ Possession	.0094	.8482
37. Disease/Health	.0094	.8576
38. Light	.0094	.8670
39. Causality	.0081	.8751
40. Weather	.0076	.8827
41. Cleanliness/ Uncleanliness	.0073	.8900
42. Popularity/ Knowness	.0072	.8972

Super-Cluster	Relative Frequency	Cumulative Relative Frequency
43. Physical Traits of People	.0071	.9043
44. Touching/ Grabbing Actions	.0069	.9112
45. Pronouns	.0069	.9181
46. Contractions	.0068	.9249
47. Entertainment/ The Arts	.0066	.9315
48. Walking/Running Actions	.0064	.9379
49. Mathematics	.0064	.9443
50. Auxiliary/ Helping Verbs	.0064	.9507
51. Events	.0061	.9568
52. Temperature/Fire	.0055	.9623
53. Images/ Perceptions	.0054	.9677
54. Life/Survival	.0053	.9730
55. Conformity/ Complexity	.0047	.9777
56. Difficulty/ Danger	.0041	.9818
57. Texture/ Durability	.0041	.9859
58. Color	.0040	.9899
59. Chemicals	.0039	.9938
60. Facial Expressions/ Actions	.0029	.9967
61. Particles of Matter	.0029	.9996

The information of primary interest from this distribution is the degree to which the first few super-clusters account for the majority of the concepts students encounter in written material, grades K-6. For example, the first fifteen super-clusters account for over 50 percent of the concepts; the first 25 super-clusters account for over 70 percent. This implies that a majority of the basic concepts may be

taught and reinforced using a relatively small proportion of the super-clusters. Preliminary findings indicate that this technique significantly escalates a student's ability to integrate these concepts into his/her reading/writing/listening/speaking vocabularies. Again, this is consistent with the vast majority of research and theory on concept learning. As Johnson (1975) states, the more extensive the links between new concepts and those already stored in memory the more meaningful learning can be said to be. At the secondary level, the basic concept clusters and super-clusters are meant to be used as a tool for students who are well below grade level in their language processing ability. They are also to be used as a framework for grouping concepts taught specifically at the secondary level.

Recognition of Relationships

To understand the skill category "Recognition of Relationships" we must first consider theory and research relative to storage of semantic and episodic information in long term memory. Recent years have seen a proliferation of models representing how information is stored in long term memory. According to van Dijk (1980, p. 206) long term memory seems to have two types of information. On the one hand it stores actually processed incoming information together with all kinds of contextual data (time, place, circumstance). This type of information is called episodic. Relative to language related information, episodic information pertains to memory for actually heard or read information. The other type of information in long term memory is the more abstract storage of concepts, belief, attitudes. This more abstract level is called semantic information. We might say that episodic information gets translated into semantic information. Episodic memory contains

information that is fundamentally autobiographical in nature; semantic memory contains facts that do not depend on a particular circumstance. Although different in terms of type of content semantic and episodic memory are considered part of the same system.

Most theories of storage of semantic and episodic information assume that the comprehension of verbal information involves the construction of propositions. Roughly speaking, propositions are "conceptual structures that are the minimal bearers of truth or satisfaction. Thus, 'John' is a concept but is not information that can be true or false...whereas 'John is ill' would be a proposition because it could be true or false." (van Dijk, 1980, p. 207). Propositions, then, are sets of concepts which together make up information that can be true or false/satisfied or dissatisfied in nature.

There is ample research evidence to show the primacy of proposition recognition in information processing. For example, Bransford and Franks (1971) found that comprehension was best characterized as a process of synthesizing information into semantic chunks that are propositional in nature. Sachs (1967) found that while memory for specific aspects of a sentence faded quickly, the memory for the propositional gist of a sentence was remarkably stable. Working with children, Pearson (1974-75) obtained results corroborating the findings of Bransford and Franks and Sachs. Propositions are so basic to the processing of information that we might say that a proposition is a good operational definition of an "idea."

We can conclude, then, that information presented verbally is first comprehended at the concept level and then at the proposition level. But organizing information into propositions is still a fairly low

level of processing. Once propositions are identified they are organized into connected sets. That is, an information processor attempts to link propositions in some meaningful way. To illustrate consider the following:

It's a nice day today but...

I'm in a bad mood.

Here there are two propositions: 1) "It's a nice day today"; 2) "I'm in a bad mood." There is a relationship between these two propositions signaled by the "linguistic connective" "but". The second skill category, "Recognition of Relationships" in the thinking skills model refers to the identification of relationships between ideas (propositions). The importance of this step in processing information is suggested from both theoretical and empirical grounds. For example, when a reader or listener comprehends information presented in linguistic form s/he attempts to identify the referential links or ties between propositions (Kintsch and van Dijk, 1978; Meyer, 1975; Waters, 1978; Kintsch, 1979). If an information processor can not identify these referential ties, the individual will backtrack until s/he can identify a link. If no linkage is found between propositions, processing breaks down.

The way in which an individual recognizes relationships between ideas is by looking for various syntactic, semantic and rhetorical signals for these relationships. For example, in the sample sentences above the word but was the signal that the two propositions had a contrastive relationship. Marzano (1983a) has identified the signals for 23 different types of relationships between propositions. To

illustrate, below are some of the words/phrases used to signal what is called an equality relationship:

and, moreover, equally, too, besides, furthermore,
likewise, similarly, as well, in addition, besides,
like.

The 23 relationships identified by Marzano are similar to those in the systems described by Halliday and Hasan (1976), Meyer (1975), de Beaugrande (1980) and Pitkin (1977). It has been shown that knowledge of these connective devices and what they mean is a significant factor in a student's ability to comprehend information presented in linguistic form (Robertson, 1968). Katz and Brent (1968) found that both first and sixth grade children preferred description of causal relationships that were made explicit by use of a linguistic connective. Their findings were corroborated by Marshall and Glock (1978-1979) who found that explicitly stated relationships facilitated the recall of prior information.

Instruction relative to relationships between ideas can proceed far beyond the level of simply teaching students to be alert for various relationship signals. Some very deep levels of abstraction can be discussed and highlighted by considering the underlying meaning signaled by the relationship. For example, consider the following:

She was beautiful but
she was not conceited.

Here there are two propositions joined by what is called a contrastive relationship. The purpose of a contrast relationship is to convey the message that the joined propositions in some way "do not go together." A student's ability to recognize this relationship would indicate one

level of awareness. Another level of awareness would be the consideration of why these two propositions "don't go together." That is, the assertion that "being beautiful" does not go with "not being conceited" implies some basic beliefs on the part of the author of these propositions. Questions and discussion which highlight this level of meaning are akin to what Doyle (1983) calls metacomprehension activities.

Recognition of Patterns

Recognition of relationships between propositions accounts for the comprehension of what is referred to as the microstructure of information. The microstructure of information is the local level of information, the literal meaning of what is explicitly stated. However, the efficient processing of information demands that ideas be organized into more global structures. In fact, it has been suggested that the process of comprehending information is that of identifying models or embedded pattern structures which fit the information (Schank, Goldman, Rieger, and Riesbeck, 1975; de Beaugrande, 1980). It is this type of processing that we refer to as recognition of patterns. There are two levels of pattern recognition. At the lowest level is the identification of what are called macro-patterns (Marzano, 1983a). These include: 1) topic macro-patterns; 2) generalization macro-patterns; 3) similarity/dissimilarity macro-patterns; 4) sequence macro-patterns; 5) process macro-patterns; and 6) embedded set macro-patterns. To illustrate one macro-pattern type, consider the following contrived example.

a) Todd's car is the nicest on the block.

b) It has red leather upholstery.

c) It does the quarter mile in 12.5 seconds.

d) It has a 430 horsepower engine.

e) It has a sun roof.

Here the topic is the concept "Todd's car." Propositions a-e all state information about the topic. A topic macropattern can be described as possessing the following characteristics: a) the propositions in the macropattern state the characteristics of a single concept; and b) a single generalization introduces or concludes the set of characteristics. The remaining five pattern types can also be described in terms of their distinguishing characteristics.

It has been shown that the extent to which higher level patterns or organizational structures of a text are made salient, the easier the information is to process and retrieve (Meyer, 1975; Kintsch, 1974; Frederiksen, 1979). Unfortunately, many texts are not written in a format that makes these patterns obvious. It has been strongly suggested (Pearson, 1981) that texts be written in more explicit patterns and that patterns be directly taught so as to facilitate comprehension.

In general, the only exposure students have to patterns is in the area of writing instruction; here students are commonly taught paradigms for writing (D'Angelo, 1980). Unfortunately, there is very little transfer of use of these paradigms to situations outside writing. Specifically, I am recommending that students be taught to recognize patterns within information they read or hear. This was the gist of the recommendations made by Anderson (1978) in his discussion of learning strategies. There is a rapidly growing body of research

which indicates that patterns can be explicitly taught and used by students to facilitate the processing and retrieval of linguistic information (Taylor & Samuels, 1983; Alexander et al., 1983; Leslie & Jett-Simpson, 1983; Greenewald & Pederson, 1983). That is, overt instruction in pattern recognition appears to improve processing of information.

A second type of pattern recognition involves the identification of what are commonly called super-structures. Super-structures are larger organizational "chunks" than macro-patterns. That is, one super-structure might contain many embedded macro-patterns strung together in a linear fashion and/or organized in some hierarchical format. Van Dijk identifies four categories of super-structures: narratives, arguments, scholarly reports and newspaper articles. De Beaugrande identifies eight types of super-structures: descriptive, narrative, argumentative, literary, poetic, scientific, didactic and conversational. Here the instructional implication is that once macropatterns are understood by students, super-structures may be introduced.

Reconstruction

Reconstruction refers to the act of organizing information for storage in long term memory. I should note here that I am using the term in a different way than is commonly found within cognitive psychology. Generally reconstruction refers to the reorganization of stored information when an individual attempts to recall information and present it in oral or written form. Here I use the term to describe the process of inputting new information rather than restructuring information already stored. I use the term because it so

graphically describes the underlying restructuring or reorganizational nature of arranging information for storage in long term memory. In other words, reconstruction demands that the individual translate the input information into some new meaningful configuration. In psycholinguistic terms, attach it to some known schema.

Van Dijk (1980; 1977) states that there are at least three components to the reconstruction process:

1) generalization: the act of identifying general concepts that subsume more specific concepts stated in the information being processed.
2) deletion: the act of deleting ideas (propositions) that are subsumed under some other stated idea.
3) construction: the act of identifying the normal conditions, consequences or components of stated ideas (propositions).

Van Dijk calls these macro-rules or rules by which an individual creates a macro-structure - the form that is used to store the information.

Translated into educationally more understandable terms, these macro-rules can be restated as follows:

1) identification of stated summary statements
2) construction of summary statements where needed
3) inference of characteristics
4) inference of causal relationships and conditions

In addition to these processes it has been suggested that the information processor infers social ramifications of the information presented when reconstructing (Bruce and Schmidt, 1974; Bruce, 1975;

Schmidt, 1975). Thus we add another category to the process of reconstruction:

5) inference of general background information

Finally, Halliday (1967) and Grimes (1972) state that in the reconstruction process the authors' stance relative to the information being presented is also inferred based on various signals given by the author. Halliday calls this theme; Grimes labels it staging. For the instructional model presented here we can label this process:

6) inference of author purpose or perspective

In summary, reconstruction refers to the act of reorganizing input information in some meaningful way so as to fit into an individual's existing knowledge base or schema. That process can be subdivided into six subprocesses. The instructional recommendation here is that students be taught and given reinforcement in these six subprocesses. More specifically, teachers would make students aware of the reconstruction process and systematically coach students through that process using stories or content area material students read.

Evaluation

Evaluating is the act of determining the: 1) logic, 2) accurateness or, 3) value of information. The logic of information refers to the extent to which a claim is supported by relevant information. Specifically Toulmin (1958; Toulmin et al., 1979) has developed a model which postulates a specific evaluation process. According to Toulmin's model there are three elements to consider when evaluating the logic of a claim: a) the data used to generate the claim, b) the "warrant" used to support the claim, and c) the "backing" used to support the warrant.

Based on this model, some fairly straightforward algorithms can be developed to guide students through the process of evaluating logic. One such algorithm is:

1) Identify claims in material read or heard.
2) Identify the proof for the claim. If no proof exists, then the claim is unsubstantiated. If unsubstantiated, does the claim fall within the domain of general knowledge?
3) If proof exists, identify any errors in logic.
   e.g., a) Assuming an incorrect cause or condition for an event;
   b) Incorrectly attributing characteristics to a concept;
   c) Assuming that concepts are similar or dissimilar on a number of dimensions when they are similar or dissimilar on only a few;
   d) Incorrectly assuming a statement falls within a generalization.
4) If no error is found, then the claim is substantiated and logical.

Evaluation of accurateness refers to the act of matching verbal input information with information that is stored in long term memory. For example, if one were to hear or read the statement "Columbus discovered America in 1493," that information or proposition would be contrasted with the individual's stored representation of the proposition. If a mismatch were found in any of the components of the propositions (input vs. stored) then the input information would be judged inaccurate. This process is similar to that described in most

"template matching" or "feature analysis" models of letter or word recognition (Lindsay & Norman, 1977; Smith, 1978), only at a higher level. The assumption here is that all verbal input information is at some level checked for accuracy against an existing schemata. Other than intuitive appeal this notion is corroborated by the research which indicates that an individual will make sense out of something that is inherently nonsensical (Lindsay & Norman, 1977). The instructional implication for this type of evaluation is that students should be made aware of the process and its limitations in terms of evaluating (e.g., you cannot evaluate that for which you have little information).

Evaluation of value refers to the act of determining whether input information is either considered good, bad or neutral on some internalized scale. Both Glaser (1981) and Powers (1973) hypothesize a cybernetic model of human information processing which asserts that input information is compared against a model of "how the world should be." The extent to which the input information matches the idealized model of what should be is the extent to which the information is considered good or bad. If information is judged as not matching the idealized "reference condition" the individual will behave in such a way as to lessen that "error" signal, thus completing the cybernetic cycle of input-comparison to reference condition-action or no action. In a similar vein, Spiro (1980) has stated that this "attitudinal" aspect of thinking is the central aspect of cognition (p. 271). He suggests more research on the order of that by Osgood, Suci and Tannenbaum (1957) and Bransford, Nitsch and Franks (1977) to further delineate the defining characteristics of value. Again the

instructional implications are that students should be made aware of the process.

Since the instructional implementation of evaluating accurateness and value both involve making students aware of the processes, we should briefly consider the purpose and merits of such an activity. When an individual becomes aware of the systems s/he used to evaluate value or logic, what are being disclosed are the "paradigms" or belief systems from which the individual operates. A natural outcome of such a disclosure is a recognition of the fact that individuals interpret reality from different perspectives. This fact is consistent with what is being described as a societal paradigm shift or a recognition of the fact that perception is by definition subjective (Skrtic, 1983; Schwartz & Ogilvy, 1979). The awareness activities described above relative to evaluation are meant to make students aware of their extant paradigms and their effects on the students' behavior.

Extrapolation

Extrapolation is the act of relating input information to a totally new context not stated in the input information. This takes the form of recognizing how some aspect of the input information is similar to or different from something within another set of information stored in long term memory. Commonly this is done at the pattern level. That is, the information processor realizes:

a) that a set of characteristics for one concept are similar to or different from a set of characteristics for some other concept.

b) that examples of one generalization are similar to or different from the examples of another generalization.

c) that one process is similar to or different from another process.

The dynamics of extrapolation are similar to those of interpreting a metaphor. For example, both metaphor and extrapolation are implicit comparisons (Alston, 1964). Both metaphors and extrapolations have a topic (that concept being likened to something new) and a vehicle (that concept to which the conventional concept is likened). Ortony (1980) states that a cognitive ability such as this develops long after a child has mastered the rudiments of language processing. However, Arter (1976) found that the use of metaphorical models facilitated the learning of low ability students.

A fairly simple algorithm which can be presented to students is:

1. identify the major patterns in the information read/heard
2. identify similar patterns for concepts not mentioned in the information read/heard

Problem Solving

Wickelgreen (1974) states that all formal problems are composed of three types of information: 1) givens, 2) operations, and 3) goals. Givens refer to the set of expressions that are present in the world of the problem at the outset of the problem. Operations refer to the actions you are allowed to perform in the givens. The goal of a problem is the terminal state one wishes to cause to exist in the world of the problem. Techniques for problem solving have been studied using such intricate analysis systems as the problem behavior graph (Newell & Simon, 1972). Lindsay and Norman (1977) summarize the various heuristics or algorithms used for problem solving. For instructional

purposes the various types of problems and their solutions can be subdivided into three major areas (Marzano, 1983b):

a) problems involving multiple overlapping operations

b) problems involving unknown operations

c) problems involving unknown or unusual givens

Although most of the research on the direct instruction in problem solving techniques have been conducted on mathematics related tasks, there are some generalizable results. When initially given an inefficient model for solving a specific problem type, students will with, with practice, transform the procedure into a more efficient routine than the one initially taught (Groen & Resnick, 1977). Instructionally, this implies that students can be given explicit models for problem solving which they will then adapt to fit their task needs. Algorithms exist for each of the three problem types mentioned above. The recommendation here is that students be taught these algorithms and presented with activities that reinforce their use. One useful tool in accomplishing this is the computer or, more specifically, instruction in computer languages (e.g., LOGO, BASIC, PASCAL). As a useful skill computer programming has a dubious future due to the projected technological advancements in user friendly hardware and software (Naisbitt, 1982). However, it has been hypothesized that the rudiments of computer programming are similar to or perhaps identical to the rudiments of general problem solving algorythms. This assertion is the underlying rationale behind the development of LOGO (Papert, 1980). Ellis (1974) has also suggested the development of general problem solving skills via instruction in programming languages. Hofmeister (1984) has identified what he calls

generalized "procedural" thinking skills which can be taught and reinforced using LOGO. Consequently, once the general problem solving algorithms have been presented to students, they can be reinforced using programming languages.

Knowledge of Basic Input/Output Processes

The basic input/output processes are here defined as reading, writing, listening, speaking or what are commonly referred to as the basic language skills. Boyer (1983) in his summary of the Carnegie Foundation study of schools states that language, not science and math, is the foundation for more complex thinking skills. This also makes a great deal of intuitive sense if one considers the theory and research on information processing. It has been hypothesized (Tulving, 1972; Shoben, 1980) that all information we receive via the senses is ultimately translated into either semantic or episodic memory. Language is the vehicle for representing semantic and episodic information. We might say that language is a "coding" of the semantic and episodic information stored in long term memory. Language, then, is a filter through which all incoming information passes before it is stored in long term memory and through which all outgoing information (that which is being communicated to somewhere else) is translated. It is no wonder, then, that the primacy of language ability as a factor in school success has been a consistent research finding (Anderson and Freebody, 1981). Indeed, the Russian psychologist Vygotsky (1978) stated that: "the most significant moment in the course of intellectual development which gives birth to the purely human form of practical and abstract intelligence, occurs when speech and practical

ability, two previously completely independent lines of development, converge" (p. 24).

The major school related language activities have been identified (DiStefano et al., 1984) as reading, writing, listening and speaking. Brown (1980) in a review of the literature on meta-cognition asserts that the good readers/writers/listeners/speakers have conscious paradigms for these processes. Hence, the thinking skill category "Knowledge of the Basic Input/output Processes" refers to explicit knowledge by the student of how to read, write, listen, and speak efficiently. Models of the reading/listening process have been constructed by Kintsch (1979); Kintsch and van Dijk (1978); Meyer (1975), Goodman (1967), Olson (1980). Models of the writing and speaking processes have been reviewed by Flower and Hayes (1981), Nold (1979), and Humes (1983). The recommendation is that students be taught specific models for each of the four input/output processes and that these models be reinforced in various content areas.

Knowledge of Content Specific Tasks

Knowledge of content specific tasks refers to an individual's knowledge of specific routines for accomplishing school related tasks not explicitly taught in the curriculum. Doyle (1983) refers to this as domain-specific knowledge. For example, assume that a literature teacher wants his/her students to be able to read poetry. According to Culler (1980) there are three key elements to the process of efficiently reading poetry:

1. "The rule of significance: read the poem as expressing a significant attitude to some problem concerning man and/or his relation to the universe." (p. 103).

2. "The conventions of metaphoric coherence - that one should attempt through semantic transformations to produce coherence in the levels of both tenor and vehicle." (p. 105).
3. "The contention of thematic entity." (p. 103) by which the reader integrates individual images into the overall image created by the poem.

Culler states that in the absence of this specific knowledge, an individual is almost totally incapable of processing the information presented in a poem:

> Anyone lacking this knowledge, anyone wholly unacquainted with literature and unfamiliar with the conventions by which fictions are read, would, for example, be quite baffled if presented with a poem. His knowledge of the language would enable him to understand phrases and sentences, but he would not know, quite literally, what to make of this literature...because he lacks the complex "literary competence" which enables others to proceed. He has not internalized the "grammar" of literature which would permit him to convert linguistic sequences into literary structures and meanings (p. 102).

Here, then, the thinking skill category, "Knowledge of Content Specific Tasks", refers to the teaching of explicit algorithms for processes which are specific to content areas (e.g., reading a map - social studies; reading a bar graph - math). For the most part these tasks are not even identified let alone described in a process sense. That is, many teachers are unaware of the content specific tasks which they expect students to master in their classes.

In the area of processes related to rules and procedures, it has been shown that effective teachers identify and explicitly teach processes or procedures they expect their students to master (Evertson, 1980). Here the suggestion is that this same procedure be done with academic tasks. That is, content area teachers would first identify the academic tasks they feel are important to their content areas. They would then identify algorithms for accomplishing each task. These algorithms would then be presented to students and activities presented for their reinforcement.

Knowledge of Self as Learner

Performance in tasks has consistently been linked with self concept or the individual's perception of self (Harter, 1983; Shavelson, Hubner and Stanton, 1970). Moreover, in those psychometric instruments designed to assess self-concept, items and subscales tapping a range of competencies have typically been included (Coopersmith, 1967; Harter, 1982; Piers and Harris, 1969). Weinstein (1982) in a review of current research indicates that there is ample evidence to support the contention that a student's view of his/her own ability relative to completing a task is important enough to outweigh teacher expectations, classroom variables and even student prior ability. In other words, student self-perceptions can be a mediating variable powerful enough to control for most other variables identified by the research as having an effect on student achievement. A program which purports to improve competence on thinking would, then, have to attend to the students' self-perception of reasoning ability. Weinstein (1982) reports on an intervention program developed by Wang which purports to increase student sense of internal control of learning tasks. Using reports

that this intervention increases self-management responsibilities which in turn increases task performance. Harmon (1982) reports that the use of affirmations and visualizations can effect student beliefs about self which in turn affect performance. The instructional recommendation here is that teachers: (1) make students aware of the fact that their beliefs affect their behavior, and (2) systematically provide classroom activities which help students create a "positive internal climate" for learning.

INSTRUCTIONAL IMPLICATIONS

In this section I will outline the instructional implications of the thinking skills model. This will not include a description of specific teaching techniques; those can be found in Marzano, (1983b). Rather the discussion will be concerned with more general instructional characteristics.

How would a classroom which utilizes the model be different from what might be called a more traditional classroom? Differences would be evident in four major areas.

1) First the concepts which are considered basic to each context area would be identified and stratified by some set of rules which account for their hierarchical structure and/or their developmental sequence. These concepts would be systematically taught and reinforced throughout the curriculum (K-12). In essence this was Klausmeier and Sipple's (1980) strong recommendation. It also fits nicely into a Piagetian model of learning in that Piaget (1970) asserts that individuals must organize the information they perceive before they can assimilate it. Such an organization of the information presented in content areas would drastically reduce the organizational load on the

student and perhaps decrease the time needed for students to capture the fundamentals within various content areas. This possibility is supported by the research review of Hyman & Cohen (1979) who recommend that the curriculum should be cut down into small digestible bites-the smaller the bite-the more immediate the closure. For some teachers in some content areas this would require a massive analysis and perhaps reorganization of their content. In essence, here I am implying that one of the reasons for the failure of some students to understand some content is that the content has not been organized for them in a "digestible" way. Concomitant with this is the assertion that the very act of organizing and presenting in basic concepts would take so much of the organizational load off students that their understanding would naturally increase.

2) Other than the hierarchical organization of content in terms of basic concepts, a classroom utilizing the model would focus on teaching processes and patterns. That is, the instructional emphasis would be on explaining, modeling and reinforcing information processing techniques and patterns of information organization. Basically, thinking skill categories 2 and 3 (recognition of relationships and recognition of patterns) deal with how information is organized-the various structures of information presentation. In the previous section we saw that there is a substantial body of literature to support the claim that the more students are aware of the patterns of organization of the information presented to them the easier that information is to process and to retrieve from long term memory. In fact, we might say that what we call intelligence is largely a function of the number of organizational structures one can recognize. There is

a fairly well known study which illustrates this assertion. At one time it was thought that the superior playing of chess masters was due to a memory advantage. This hypothesis was tested by de Groot (1965) in a study which required chess masters and nonmasters to view chess boards for a brief period of time. The masters and nonmasters viewed the boards under two conditions. Under one condition the chess pieces were set in patterns commonly used in play. Under the other condition the chess pieces were arranged randomly. After viewing each chess board the subjects were asked to reconstruct the arrangements. If the chess masters do have a memory advantage, one would assume that they would have better recall under both conditions. In fact, they had better recall only under the condition where the pieces were arranged in familiar patterns of play. Under the random condition the chess masters performed no better than the nonmasters. The explanation for this is that the chess masters had internalized a number of patterns of organization for chess pieces during various stages of play. When pieces were arranged in those patterns the masters recognized the patterns and consequently could store and retrieve the information quite efficiently. When they could not find a recognizable pattern among the pieces their recall was no better than the nonmaster. Translated to general information processing, the mature reader/listener notices the organizational patterns in the information being processed. S/he encodes these patterns and then uses them as retrieval cues when recalling the information (Shimmerlick, 1979). Such a notion is also consistent with Ausubel's (1963) subsumer theory. Using the thinking skill categories 2 and 3, teachers would be reinforcing the patterns of information found in content area texts. Rather than focus

on the content of the material, teachers would help students understand the patterns of organization of the material so that they could better process the content.

Thinking skills categories 4-10 all deal with specific processes-the process of organizing information for storage in long term memory-the processes of evaluating-the processes of problem solving, etc. Relative to these skill areas the teacher would systematically model with students the various processes using the subject matter content as the material to be processed. This modeling aspect of instruction has been strongly recommended by Hunter and Breit (1976). Modeling would take the form of what is called verbal mediation. Verbal mediation is the use of language as an internal regulator and tool of rational thought (Camp and Bash, 1981). In its simplest form, verbal mediation has been described as talking to oneself to facilitate the accomplishment of a task (Jensen, 1966; Meichenbaum, 1977). In essence, verbal mediation is the explicit description of the process required to accomplish a task. Apparently, the very act of "languaging" a process makes it more salient and consequently more useful. Luria (1961) and Vygotsky (1962) describe a developmental sequence in this ability and Jensen (1966) states that it is the biggest difference between humans and apes. The purpose of modeling, then, would be to model and reinforce the paradigms for the processes described in the thinking skills categories 4-10. Research has already indicated (Resnick and Ford, 1981) that the ability to accomplish a school-related task is strongly related to the individual's knowledge of a paradigm or algorithm for accomplishing the task. Modeling via verbal mediation would provide a direct way of teaching processes.

3) As a consequence of the use of modeling, there would be a high degree of interaction between teacher and students. Specifically, there would be more direct teaching of heterogeneous groups. Such a notion is quite consistent with what has come to be known as the effective schools research. Good, Grouws and Ebmeier (1983) found that effective teachers used direct teaching with their classes as a whole a larger percent of time and spent more time explaining and interacting with students than did less effective teachers. Rosenshine (1979) found that students spend more time off task when they work alone and are more successful during whole class interaction. Stallings (1982) found that if students give an incorrect response it is important that the teacher interact with the student about the response rather than move on to another student for the correct response. This interaction helps clarify for the student why his/her response is inaccurate and provides an opportunity for incidental learning for the rest of the students who are observing the interaction. Relative to teacher/ student interaction the thinking skills categories would provide a framework within which teacher and students could interact for an extended period of time at deeper levels. More specifically the patterns of organization and processes taught to students would provide a common vocabulary between teacher and students which would be used to expand and extend student/teacher interaction. For example, teachers and students could discuss the relative merits of one student's evaluation because all share common patterns of evaluation; teacher and students could discuss different ways of interpreting information because they share a common knowledge of patterns of information organization. This common vocabulary between teacher and student would

be a tool which could be used to facilitate teacher/student interaction.

4) Finally, the system of student evaluation used in a school which implemented the thinking skills model would be greatly expanded and more specifically delineated. Current standardized multiple choice tests, although similar in surface appearance, require a wide range of abilities to answer different items. Items from a given test are scored together yet no attempt is made to isolate specific skills measured by each item. For example, Wardrop (1970) reviewed standardized reading achievement tests and noted that "comprehension subtests differ markedly in content passages presented, lengths of passages, type of behavior required for responding correctly, number of test items per reading passage and readability of the content presented." Wardrop asserts that the operational definition of reading comprehension seems to have become a function of the test author's idiosyncratic feelings about the construct, and in only a few isolated cases have efforts been made to underpin item development with construct theory.

In light of this we cannot assume that standardized tests would discriminate well among the various thinking skill categories. That is, it would be difficult to predict which item or item categories would be affected by a gain or mastery of specific thinking skill categories. In addition, many of the thinking skill categories deal with the reinforcement of processes (e.g., categories 4-10). A student's knowledge and use of these processes probably cannot be measured via a multiple choice test. All of this implies that: a) more specific item types will have to be created to measure the

thinking skill categories, and b) alternate forms of evaluation must be created which allow students to provide more information than the selection of an item from among alternatives. Relative to implication a above, an item bank is being created which isolates specific skills within the model. Relative to b a ready-made vehicle is essay-type questions which require students to describe how they would accomplish a specific task (e.g., how they would solve a problem or evaluate a piece of information). These answers would then be scored only for their adherence to the particular model presented to the student for the process being tested. Such a scoring system could be easily adapted to primary trait scoring procedures (Lloyd-Jones, 1977). In this same vein, teachers could use more informal means of diagnosing a student's knowledge and use of processes by observing students performing tasks and/or asking students to describe the process they are using to accomplish the task (verbal mediation).

CONCLUSION

In this paper an instructional model for thinking skills has been presented along with the research and theory supporting it and a discussion of its implementation. In its present form that model is implementable at any grade level within any instructional framework because its focal point is the teacher and his/her interaction with students. At a basic level the thinking skills model is simply a framework within which teachers can interact with students about information. The relationships, patterns and processes taught students provide a common vocabulary between teacher and students-a vocabulary that can be used to explore new arenas of thought. For this expansion of the domain of education a price must be paid-that price is our

attachment to "coverage" of a certain number of workbooks, stories, problems, etc., within a given period of time. As de Bono (1983) states, "we may have to reduce the time we spend teaching information in order to focus instead on the direct teaching of thinking skills", (p. 704). Given the future trend of increased need for information processing ability (Naisbitt, 1982), we have little choice in the matter if we are to meet our obligation of fair and relevant education for all.

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